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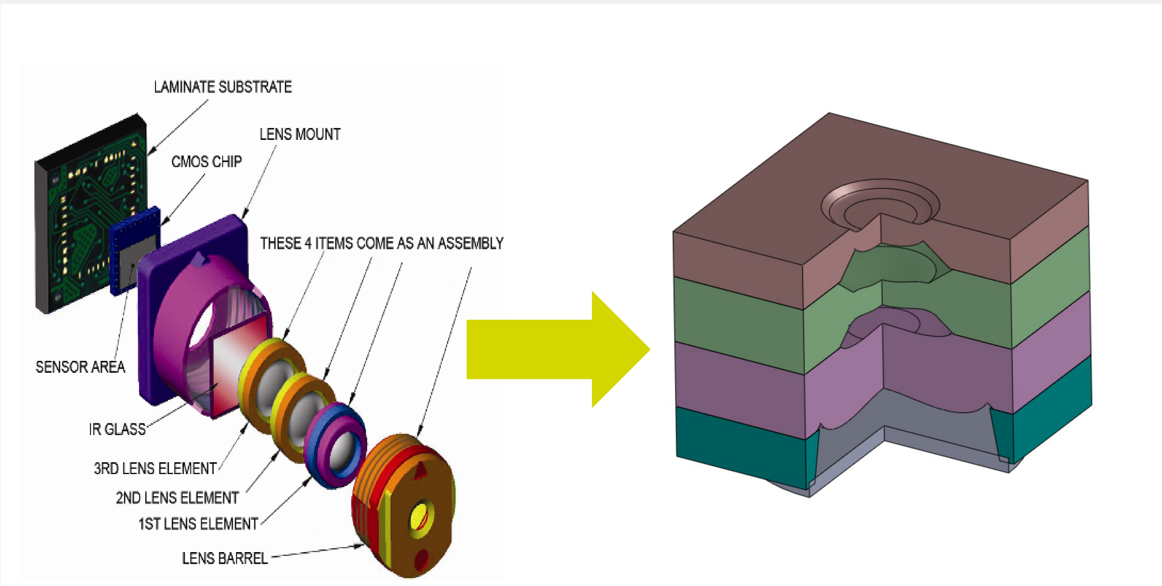
DTU Nanotech
Department of Micro- and Nanotechnology

Towards Wafer Based Fabrication of Precise Optical Polymer Elements

Jirka Cech and Rafael Taboryski

Abstract: We aim to develop a processes to form precise free form lens elements on wafer level scale, using PMMA and advanced heat-resistant polymers, capable of a reflow assembly. Such optical elements can be used to prepare stacked, multi-level camera modules for the applications in portable electronics, using wafer level packaging techniques. Calculation shows significant cost advantage over discrete assembly built camera modules. Nanostructured surface of lenses can provide antireflective or self-cleaning properties so nanostructures on lens surfaces were formed.



Conventional camera module consisting of multiple discrete components as opposed to wafer level assembly based modules, where one prepares 3000 – 4000 dies with complete modules at once on 4" wafer.

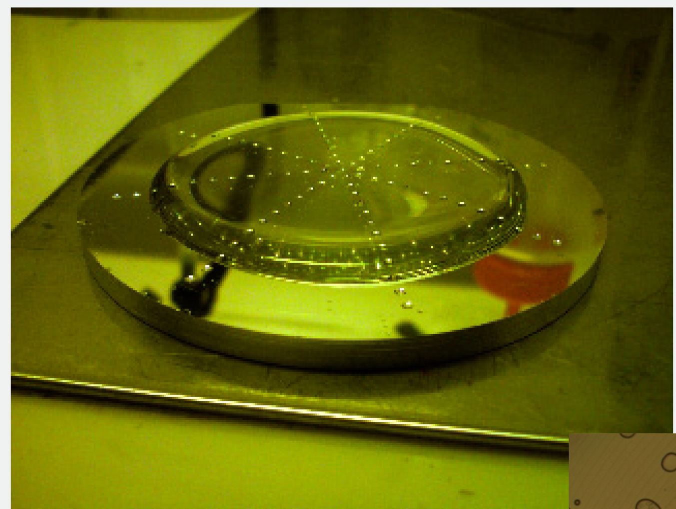
Motivation

Use well established semiconductor fabrication principles of integration, parallelization, wafer level manufacturing. This allows to make more precise, advanced optical design (aspheric) using automated processing. Cost for single wafer level camera module (3 lens stack, 3 spacers and 3 MPix sensor) was calculated to be $1.26 with 80% yield.

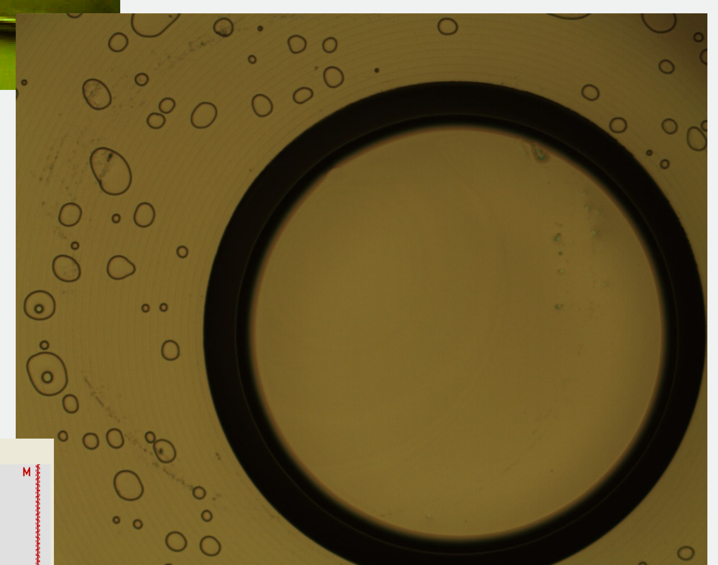
Approach

- Make wafer sized master for lens surfaces
- Replicate lenses
- Prepare wafers with apertures, filters, spacers,
- Wafers with CMOS sensors
- Readout circuitry
- Stack, Align,
- Bond, Cure it
- Dice
- Mount to baseboard
- Test

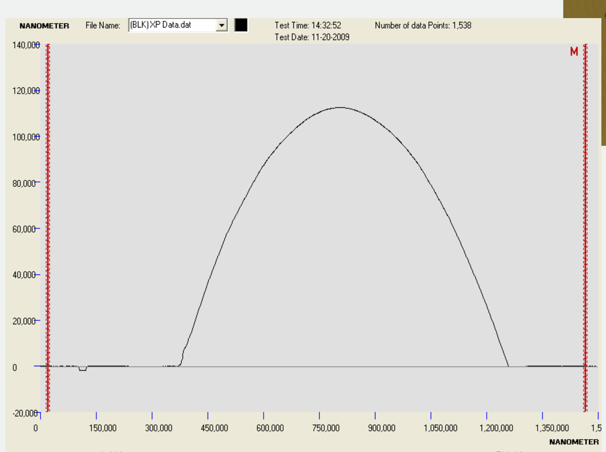
Initial Results with Ormocer



Aluminum tool with microlenses
Special anti-adhesion coating
Spreading via spin coating
Ex-situ UV curing
Post-exposure bake



Optical microscopy image
Polymer outside lenses
Bubbles outside lenses
Nonconforming shape

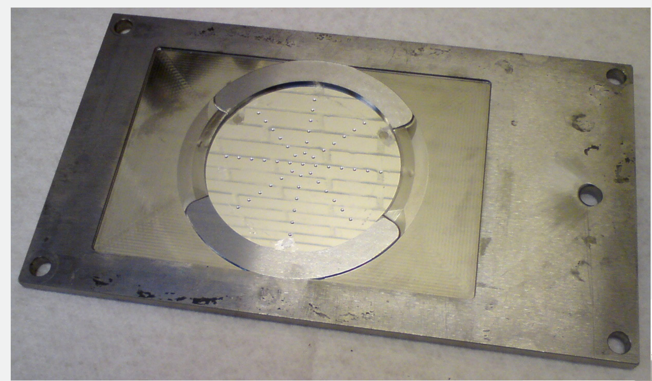


Mechanical profilometry
Diameter 1.0 mm
Curvature radius 1.0 mm
Sag 120-135 microns

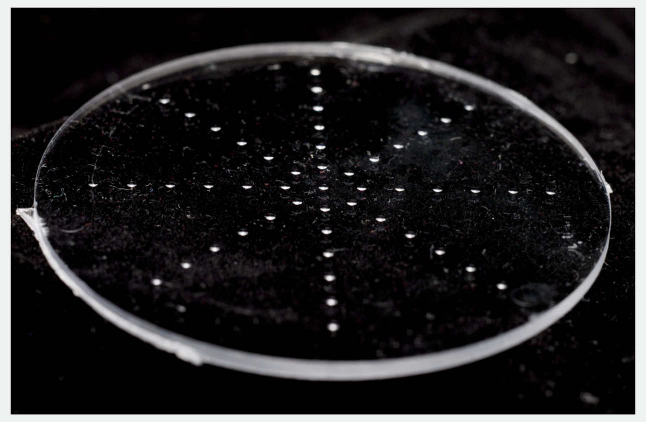
Ex-situ curing does not warrant sufficient precision, uniformity and yield. Thermally curable composition with suitable optical properties, low stress, low shrinkage and high temperature resistance would allow to use in-situ curing.

Initial Results with Polystyrene

Injection molding modified tool insert.



Engel e-motion 55 system
PS with Tg ~ 100 °C
60 mm disc, 1.5 mm thick
Lens sag 134 microns



Acknowledgments

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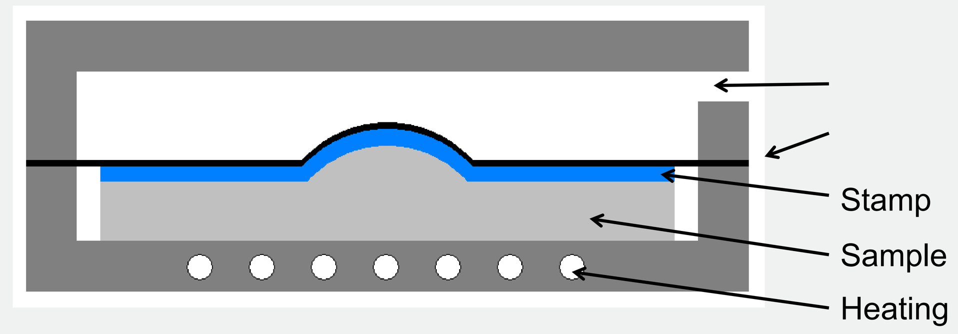
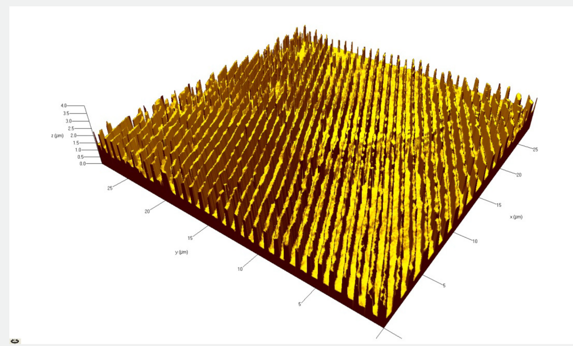
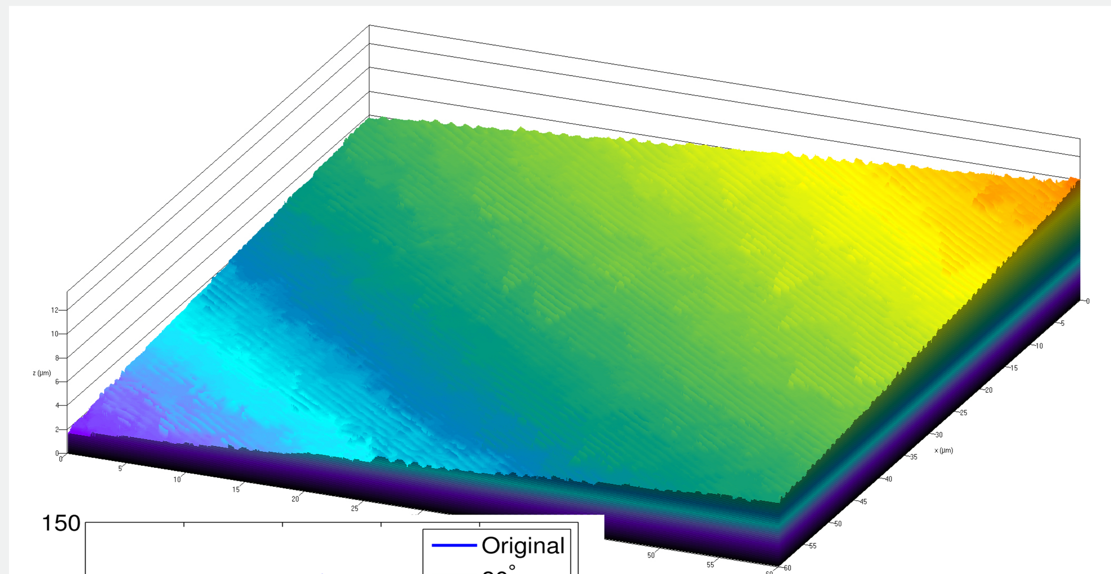
Nanostructures on double curved surface

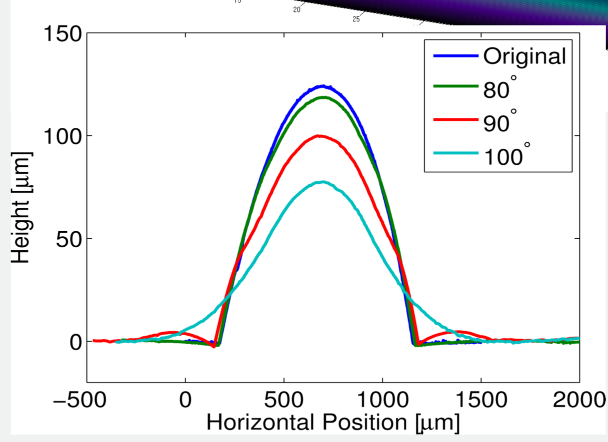
Pattern created on Injection molded PS substrates with microlenses was formed by hydrostatic embossing with Obducat 2.5 NIL. Flexible stamp is 188 micron thick polymer foil from Nickel master.





LS Confocal microscopy
770 nm pattern period
Pattern on 10% sloped surface with high uniformity





Macrostructure deformation as a function of nanoimprinting temperature

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